The object of writing *m* for *w*/*g*, or of changing to the absolute unit of force and writing *m* for *w*, is merely to get rid of *g* in the dynamical equations, which concern the problems which alone are capable of direct human measurement.

But this quantity *g*, so treacherous as Dr. Lodge can testify, should always be kept carefully in sight; any attempt to get rid of it merely causes it to reappear elsewhere in an unexpected place (*expelles furca*, &c.).

The engineer can be left to take care of himself, and does not require to be instructed in an art with which he is perfectly familiar. Considering that he has been compelled to create for himself, without professorial assistance, the whole theory of the internal stresses of rapidly reciprocating machinery as causing vibration, it cannot be correct to say that *acceleration* does not come under his notice.

Certainly he often ignores acceleration in his dynamical equations, but that is because he prefers to use the principles of Energy and Momentum; and our elementary text-books would do well to imitate him.

As for Dr. Lodge's hint to the sailor, it is useless and even dangerous for navigation, because it gives the distance of the offing in military land miles; instead of geographical nautical miles, as required, of sixty to the degree.

I am reminded of another delicious hint from a theorist to practical men, taken from a recent text-book of Theoretical Mechanics; the gunner is instructed not to use his favourite whip-on-whip tackle, nor the sailor to set up the backstay in the usual manner, because the theoretical writer finds the Third System of Pulleys practically useless, the strings of his model always becoming twisted.

An engineer can generally be provided with some quiet enjoyment in looking through the pages, and especially the diagrams, of our numerous treatises on Elementary Mechanics, and he will smile at the mental pabulum chopped up small for the benefit of the rising pedagogue.

In this discussion, Prof. T. W. Wright's excellent Mechanics has been lost sight of; it is a complete contrast to our ordinary elementary text-book.

I thoroughly agree with Prof. Wright that the introduction of the *poundal* has done more harm than good, and that it will never be employed, even by Electricians always working in absolute units, who will confine themselves to the Metric System.

The world will never take kindly to saying that the weight of a pound weight is 32·1912 poundals, so long as it is at rest on the table; but that the weight changes immediately to 32·2382 poundals when we toss the weight in the air.

February 6. A. G. GREENHILL.

Symbols of Applied Algebra.

I AM sorry to trouble you with one more letter on this subject. Prof. Lodge objected to the energy formula $wv^2/2g$, and stated that he could only bestow his approbation on a formula which was "independent of every system of units." His example of such a formula involved three quantities of the same kind—namely, three lengths. Being invited to give a formula involving three different quantities—*e.g.* weight, volume, and specific gravity—which should come up to his standard, he gives $W = sV$. Now this formula is certainly independent of every system of units, in the sense that it cannot be used with any known system of units (not even accurately with the C.G.S. units).

To bring out this point, I inquired how this formula is to be used with the poundal. Prof. Lodge observes, in reply, that density is not a mere number, and that specific gravity may be measured in pounds per cubit foot. The former statement is irrelevant; the latter not true if "specific gravity" is taken with the meaning with which it is invariably used.

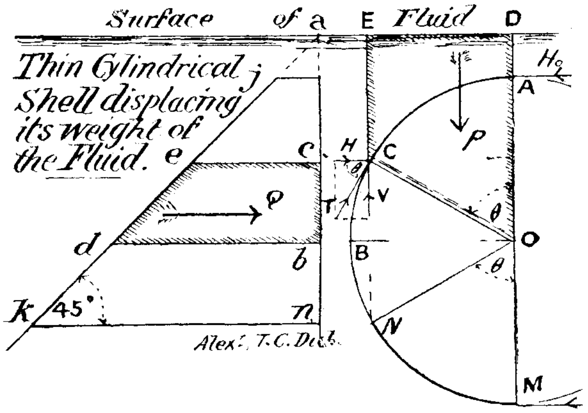
Dr. O'Reilly overlooks, I venture to think, the difference between postponing the consideration of the idea of "mass," and confusing it with "force." Of course, his comment on the formula $P/Q = f/a$ is perfectly correct. C. S. JACKSON.

Equilibrium of a Cylindrical Shell.

AMONG some work on the design of arches which Dr. Thomson, of the Science College, Poona, and myself are preparing for publication in the engineering journals, the following elegant case of the equilibrium of a circular rib occurs. As it admits of a simple physical enunciation and a simple geometrical proof, I think it may interest your readers.

A thin hollow cylinder with a uniform circular shell is submerged in a fluid, and is lying with its axis horizontal. The fluid is excluded from the cylinder by smooth face-plates of the same density as the fluid. The weight of the shell is such that the cylinder displaces its own weight of the fluid. It is evident, then, that the cylinder, as a whole, is in neutral equilibrium, at any depth below the surface. But, further, if the shell be supposed to be perfectly flexible and incompressible, it is still in equilibrium under its own weight and the fluid pressure.

Let the figure represent a ring of the cylinder one foot long, normal to the paper, and let the unit of weight be that of a cubic foot of the fluid. Consider the equilibrium of the arc A C, and it will be seen that V, the vertical component thrust at C, is given by the area of the shaded trapezium E D O C, made up of the superincumbent mass of fluid E D A C, and the weight of the arc A C, which is exactly equal to the fluid mass O A C it displaces.



Again H, the horizontal component thrust at C is given by the area of the shaded trapezium *b c e d*, for H_0 has to balance the whole figure *b j* when the equilibrium of the quadrant A B is considered, and has to balance H together with *c j* when the equilibrium of the arc A C is considered.

Now the two shaded trapeziums have their parallel sides equal each to each, so that their areas are proportional to the distances between their pairs of parallel sides. Hence

$$H : V :: Q : P :: bc : ED :: \cos\theta : \sin\theta,$$

and it follows that the thrust at C is along the tangent to the circle there. In the same way the horizontal and vertical component thrusts at N are given by *n d* and N D, and are again proportional to cosine θ and sine θ. THOS. ALEXANDER.

Engineering School, Trinity College, Dublin, February 9.

Oysters and Copper.

As Prof. Herdman, in his interesting letter on the oyster question, appears to doubt the occurrence of copper in oysters, it may be of interest to mention that, quite recently, I examined some oysters containing this metal in considerable quantity, a single oyster yielding ·04 grammes (about $\frac{5}{8}$ grain) of copper.

Some of the oysters were light blue in colour, and others were a dark olive-green, and copper was found in both.

These oysters had been obtained from the Mumbles, near Swansea. W. F. LOWE.

Assay Office, Chester, February 4.

I AM interested to hear of Mr. Lowe's case, where he considers the oysters from near Swansea owe their colour to a very considerable amount of copper. As I stated in the concluding paragraph of my last letter (p. 293), "It is evident that there are several distinct kinds of greenness in oysters." Amongst these I cited Dr. Thorpe's recent demonstration of notable amounts of copper in oysters from Falmouth; so it can scarcely be said that I "appear to doubt the occurrence of copper." Dr. Charles Kohn has kindly re-investigated the matter for me

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lately, and has determined the amounts of both copper and iron present in various kinds of oysters by electrolytic methods. He finds the green Marennes oyster contains about 0·4 mgrme. (say ·006 grains) of copper, which agrees pretty closely with the figures given by previous writers. This seems to be the normal amount present in all oysters, white or green, and due to the hæmocyanin of the blood. Dr. Thorpe, however, finds that the green Falmouth oysters have, on the average, each ·023 grains of copper, which falls to the normal amount (·006) on re-laying in another locality, and which is "obviously caused by the mechanical retention of cupriferous particles" (Thorpe, NATURE, p. 107). If Dr. Thorpe means by this that copper mud is entangled in the water and food passages of the oyster, is it not possible that, although the oyster is green, and copper is present, the colour may be due—as in most green oysters—to another cause? This mere entanglement (more or less accidental) of copper-bearing material in the passages of the oyster may also be the explanation of the extraordinarily high figure reported by Mr. Lowe—a figure (·04 grammes) as large, I may remark, as that of the *total ash* in the case of some of my oysters investigated by Dr. Kohn. W. A. HERDMAN.

Liverpool, February 6.

Immunity from Snake-Bite.

IN regard to the immunity from the danger of a second bite which a non-lethal dose of snake venom affords an animal, and also in regard to the question of antitoxin, I would suggest that the comparatively simple case of the sting of bees might be investigated.

The keeper of an apiary once told me that when he first took charge of it, he was laid up for some days by the intense inflammation due to the stings, but that he soon became quite indifferent to the venom. I myself saw him stung several times during a few minutes while he was emptying one hive into another. He had no protection over his hands and face, and, except for the sharp prick of the actual sting, he suffered no ill-effects.

May not the stinging liquid, generally assumed to be formic acid, be of the same nature as snake venom? Might not formic acid have the same effect? R. C. T. EVANS.

SUBJECTIVE COLOUR PHENOMENA.

IN a recent communication to the Royal Society,[1] I described a series of optical experiments which originated in an attempt to account for the colour phenomena exhibited by Mr. C. E. Benham's "Artificial Spectrum Top" (NATURE, vol. li. p. 113). The chief of these experiments are of an exceedingly simple character, and can easily be repeated without the employment of any special apparatus. They demonstrate the formation, under certain conditions, of transient bands of colour along the boundaries between light and dark surfaces.

Let a hole, half an inch square, be cut with a sharp knife in the middle of a sheet of thick brown paper about 15 inches square. The hole is to be covered with gummed white paper taken from the edge of a sheet of postage stamps ("stamp paper"); a small translucent window is thus formed. Across the middle of the window a common pin is to be fixed, like a bar, by means of narrow strips of stamp paper at its two ends. Holding the brown paper in the left-hand between the eyes and a lamp, the observer directs his eyes upon the translucent window; then he conceals it from view by interposing a screen, such as a thin book with a dark cover. After a few seconds, and without moving the eyes in the meantime, he suddenly withdraws the screen; then, if everything is right, and the observer is not unaccustomed to subjective visual experiments, the window will, for a moment after its exposure, appear to be surrounded by a narrow red border, while the pin also will at first appear bright red, not turning black until after the lapse of about one-tenth of a second. The effect is seen best when the lamp is at a certain distance from the brown paper. This distance must be found by trial; in my own case an eight-candle power lamp gives good results when it is about 12 inches behind the paper. The observer's eye should be 10 or 12 inches away from the translucent window.

When once the red border has been detected, it becomes very conspicuous; the difficulty in the first instance being not to see it, but to know that one sees it. The phenomenon is, without doubt, constantly met with, and habitually ignored, in daily life. Since my first observation of it I have many times noticed flashes of red upon the black letters of a book, or upon the edges of the page: bright metallic or polished objects often show a red border when they pass across the field of vision in consequence of a movement of the eyes, and it was an accidental observation of this kind that suggested an experiment like the following:—

Holding the brown paper between his eyes and the lamp, as before, the observer moves it rather quickly either up and down, or round and round in a small circle an inch or two in diameter. The moving window will, owing to persistence, form a straight or circular luminous streak, which will appear to be bordered on both sides with bright red. No person, however unpractised, to whom I have shown this experiment, has failed to see the red border at once. As before, the intensity of the illumination must be properly regulated; so also must the speed of the movement. With strong illumination the red border is very narrow, and is lined with greenish-blue; or the red colour may even be altogether absent.

The above experiments show that when a luminous image (not too bright) is suddenly formed upon the retina, it appears at first to be surrounded by a red border.

The following is a way of showing the same effect by reflected instead of by transmitted light. Two or three black lines, about as thick and as long as an ordinary pin, are drawn upon a small piece of white paper, which is placed upon a table and illuminated by strong lamp-light (not daylight). A black book is interposed between the observer's eyes and the paper, and then very suddenly withdrawn; the lines, when first seen, appear to be red, quickly changing to black. So far the observation is a rather difficult one, but by a very simple device it is possible to obliterate the image of the lines before the redness has had time to disappear; the colour then becomes easily perceptible. A thin black book is held horizontally in the right hand by its left-hand bottom corner, the thumb being uppermost; between the thumb and the book is inserted the right-hand bottom corner of a sheet of white note-paper; the upper right and left corners of the paper and the book respectively are separated, so as to form a triangular open space between them. The book is held an inch or two above the black-lined paper, covering it completely; then the hand is quickly moved from left to right in such a manner that the lines are for a moment exposed to view through the gap between the book and the note-paper, the movement being stopped as soon as the lines are covered by the paper. During the brief glimpse that will be had of the lines while they are beneath the gap, they will, if the illumination is correct, appear to be of a brilliant red hue. It must be ascertained by a preliminary trial that neither the book nor the note-paper casts a shadow upon the black lines when the gap is passing over them.

By a further simple contrivance the red images may be made visible almost continuously for an indefinite time. Upon a disc of white cardboard, from 3½ to 6 inches in diameter, two straight lines are drawn from the centre to the circumference, containing an angle of about 45°; the portion enclosed by the lines is cut out nearly up to the centre, a rim about ¼ inch wide being left at the circumference; the remainder of the disc is divided into two equal parts by a straight line from the centre to the circumference, opposite the opening, and one of these parts is painted black with ink. A pin is passed through

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[1] "On Subjective Colour Phenomena attending sudden Changes of Illumination." (*Proc. Roy. Soc.*, December 17, 1896.)

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